LETTERS

Oxytocin increases trust in humans

Michael Kosfeld[1]*, Markus Heinrichs[2]*, Paul J. Zak[3], Urs Fischbacher[1] & Ernst Fehr[1,4]

Trust pervades human societies[1,2]. Trust is indispensable in friendship, love, families and organizations, and plays a key role in economic exchange and politics[3]. In the absence of trust among trading partners, market transactions break down. In the absence of trust in a country's institutions and leaders, political legitimacy breaks down. Much recent evidence indicates that trust contributes to economic, political and social success[4,5]. Little is known, however, about the biological basis of trust among humans. Here we show that intranasal administration of oxytocin, a neuropeptide that plays a key role in social attachment and affiliation in non-human mammals[6–8], causes a substantial increase in trust among humans, thereby greatly increasing the benefits from social interactions. We also show that the effect of oxytocin on trust is not due to a general increase in the readiness to bear risks. On the contrary, oxytocin specifically affects an individual's willingness to accept social risks arising through interpersonal interactions. These results concur with animal research suggesting an essential role for oxytocin as a biological basis of prosocial approach behaviour.

In non-human mammals, the neuropeptide oxytocin has a central role in general behavioural regulation, particularly in positive social interactions. Aside from its well-known physiological functions in milk letdown and during labour, oxytocin receptors are distributed in various brain regions associated with behaviour[9,10], including pair bonding, maternal care, sexual behaviour, and the ability to form normal social attachments[6–8,11–15]. Thus, oxytocin seems to permit animals to overcome their natural avoidance of proximity and thereby facilitates approach behaviour. Given that oxytocin is believed to promote social attachment and affiliation in non-human mammals, we hypothesized that oxytocin might also promote prosocial approach behaviours—such as trust—in humans. Recent research has shown that neuropeptides cross the blood-brain barrier after intranasal administration[16], providing a useful method for studying the central nervous system effects of oxytocin in humans[17,18]. We used a double-blind study design to compare trusting behaviour in a group of subjects that received a single dose of intranasal oxytocin with that of subjects in a control group that received placebo.

We analysed the effect of exogenously administered oxytocin on individuals' decisions in a trust game with real monetary stakes[19–22]. In this trust game, two subjects interacting anonymously play either the role of an investor or a trustee (Fig. 1). First, the investor has the option of choosing a costly trusting action by giving money to the trustee. If the investor transfers money, the total amount available for distribution between the two players increases but, initially, the trustee reaps the whole increase. The trustee is then informed about the investor's transfer and can honour the investor's trust by sharing the monetary increase generated by the investor's transfer. Thus, if the investor gives money to the trustee and the latter shares the proceeds of the transfer, both players end up with a higher monetary payoff. However, the trustee also has the option of violating the investor's trust. As sharing the proceeds is costly for the trustee, a selfish trustee will never honour the investor's trust because the investor and the trustee interact only once during the experiment.

The investor is therefore caught in a dilemma: if he trusts and the trustee shares, the investor increases his payoff, but he is also subject to the risk that the trustee will abuse this trust. In the latter case, the investor is worse off than if he had not trusted at all and, adding insult to injury, the trustee has an unfair payoff advantage relative to the investor. Substantial evidence exists to show that humans are averse to such risks[22–24]. Moreover, the aversion of investors to abuse of trust seems to have an important role across different human cultures and social groups in the context of our game[22,25]. The investors have to overcome their aversion against these risks in order to trust, allowing us to address the question of whether oxytocin modulates this trusting behaviour in humans.

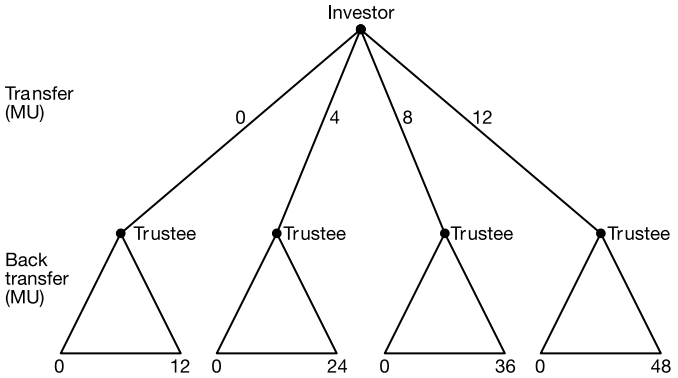

Figure 1 | The trust game. Both subjects receive an initial endowment of 12 monetary units (MU). The investor can send 0, 4, 8 or 12 MU to the trustee. The experimenter triples each MU the investor transfers. After the investor's decision is made, the trustee is informed about the investor's transfer. Then the trustee has the option of sending any amount between zero and his total amount available back to the investor. For example, if the investor has sent 12 MU, the trustee possesses 48 MU (12 MU own endowment + 36 MU tripled transfer) and can, therefore choose any back transfer from 0 to 48 MUs. The experimenter does not triple the back transfer. The investor's final payoff corresponds to the initial endowment minus the transfer to the trustee, plus the back transfer from the trustee. The trustee's final payoff is given by his initial endowment plus the tripled transfer of the investor, minus the back transfer to the investor. At the end of the experiment, the earned MU are exchanged into real money according to a publicly announced exchange rate (see Methods). Each subject made four decisions in the same player role while paired with four different, randomly selected interaction partners.

[1]University of Zurich, Institute for Empirical Research in Economics, Blumlisalpstrasse 10, CH-8006 Zurich, Switzerland. [2]University of Zurich, Department of Clinical Psychology and Psychotherapy, Zurichbergstrasse 43, CH-8044 Zurich, Switzerland. [3]Center for Neuroeconomics Studies, Claremont Graduate University, Claremont, California 91711-6165, USA. [4]Collegium Helveticum, Schmelzbergstrasse 25, CH-8092 Zurich, Switzerland.
*These authors contributed equally to this work.

© 2005 Nature Publishing Group

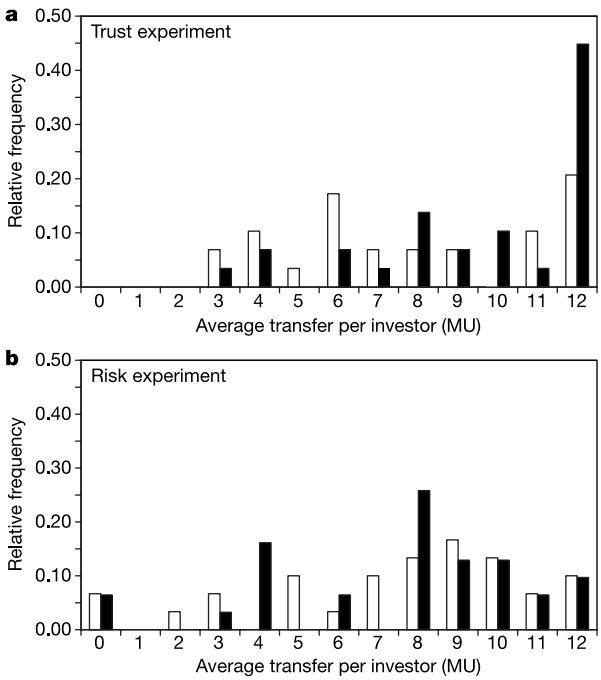

Figure 2 | Transfers in the trust and the risk experiment. Each observation represents the average transfer amount (in MU) over four transfer decisions per investor. **a**, Relative frequency of investors' average transfers in oxytocin (filled bars) and placebo (open bars) groups in the trust experiment ($n = 58$). Subjects given oxytocin show significantly higher transfer levels. **b**, Relative frequency of investors' average transfers in oxytocin (filled bars) and placebo (open bars) groups in the risk experiment ($n = 61$). Subjects in the oxytocin and the placebo group show statistically identical transfer levels.

Our hypothesis that oxytocin increases the trusting behaviour of investors implies that the investors in the oxytocin group ($n = 29$) will show higher money transfers than those in the placebo group ($n = 29$). In fact, our data show that oxytocin increases investors' trust considerably. Out of the 29 subjects, 13 (45%) in the oxytocin group showed the maximal trust level, whereas only 6 of the 29 subjects (21%) in the placebo group showed maximal trust (Fig. 2a). In contrast, only 21% of the subjects in the oxytocin group had a trust level below 8 monetary units (MU), but 45% of the subjects in the control group showed such low levels of trust. These differences in the distribution of trust result in higher average and median trust levels for subjects given oxytocin (Table 1). The investors' average transfer is 17% higher in the oxytocin group (Mann-Whitney *U*-test; $z = -1.897$, $P = 0.029$, one-sided), and the median transfer in the oxytocin group is 10 MU, compared to a median of only 8 MU for subjects in the placebo group.

In the trust game, the risk on the part of the investor's is due to the uncertainty of the trustee's behaviour—that is, a social interaction with a specific trustee constitutes the risk. This raises the question of whether oxytocin helps humans to overcome a general aversion against risks or whether oxytocin specifically affects trusting behaviour in social interactions. In order to answer this question, we conducted a risk experiment in which the investor faced the same choices as in the trust game but in which a random mechanism, not the trustee's decision, determined the investor's risk. The random mechanism in the risk experiment replicated the trustees' decisions in the trust experiment. Therefore, the investors faced exactly the same risk as in the trust experiment (see Methods); however, their transfer decisions were not embedded in a social interaction because there were no trustees in the risk experiment.

In this risk experiment, the investors' behaviour does not differ between the oxytocin and the placebo groups (Table 1 and Fig. 2b). The median transfer is 8 MU and the average transfer is 7.5 MU in both groups (Mann-Whitney *U*-test; $z = 0.022$, $P = 0.983$; two-sided test, $n = 31$ in oxytocin group, $n = 30$ in placebo group). Moreover, there is no significant difference in a comparison of the placebo group in the trust experiment with the oxytocin group and the placebo group in the risk experiment (Kruskal-Wallis test; $\chi^2 = 0.533$, d.f. $= 2$, $P = 0.766$), with identical median transfers across groups (Table 1). However, if we add the oxytocin group in the trust experiment to these three samples, significant differences are observed (Kruskal-Wallis test; $\chi^2 = 8.610$, d.f. $= 3$, $P = 0.035$), indicating that only the investors in the oxytocin group of the trust experiment behave differently. Thus, oxytocin increases the investors' transfer levels in the trust experiment but not in the risk experiment. This finding is illustrated by a comparison of Figs 2a and b, which show that only 10% of the subjects with oxytocin choose the maximal transfer level in the risk experiment, whereas 45% choose the maximal level in the trust experiment. Therefore, the differences between the oxytocin group in the trust experiment and the oxytocin group in the risk experiment are highly significant (Mann-Whitney *U*-test; $z = -2.563$, $P = 0.010$, two-sided), suggesting that oxytocin specifically affects trust in interpersonal interactions.

The risk experiment constitutes a powerful control for the effects of oxytocin on trusting behaviour because everything is kept constant relative to the trust experiment, except that the investors' risk in the risk experiment is not generated through a social interaction. Specifically, all the indirect effects of oxytocin on the state of a subject, such as possible effects on mood or calmness, would be present in both the trust and the risk experiment. Therefore, these potential indirect effects of oxytocin cannot be responsible for the effect of oxytocin on trusting behaviour. Moreover, in order to provide an additional control for non-specific effects that might be associated with oxytocin administration, we explicitly measured mood and calmness before substance administration and 50 min after administration (but before subjects played the trust or the risk game). We used a questionnaire suitable for repeated measures within short periods of time, one that is widely used in neuropharmacological studies in humans[26] and correlates with physiological measures[17]. There were no statistical differences in the levels of mood and calmness before and after the administration of oxytocin in either the trust or the risk experiment. (Trust experiment: $z = -1.541$, $P = 0.123$ for calmness; $z = 1.452$, $P = 0.146$ for mood; $n = 29$. Risk experiment: $z = 0.620$, $P = 0.535$ for calmness; $z = -0.841$, $P = 0.400$ for mood; $n = 31$; two-sided Wilcoxon signed rank tests.) This provides further support for our conclusion

Table 1 | Median and average transfer behaviour of investors

	Trust experiment		Risk experiment	
	Oxytocin group	Placebo group	Oxytocin group	Placebo group
Mean average transfer (MU)	9.6	8.1	7.5	7.5
Median average transfer (MU)	10	8	8	8
Standard deviation of transfers (MU)	2.8	3.1	3.3	3.4
Number of observations	29	29	31	30

© 2005 Nature Publishing Group

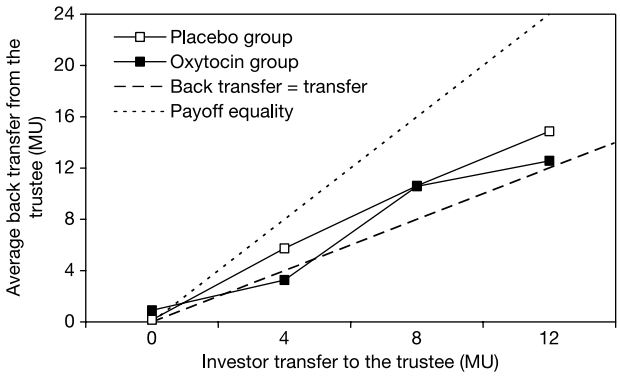

Figure 3 | Average back transfer of trustees to their investors. The graph shows the average back transfer by trustees for different levels of investor transfer in the oxytocin and placebo groups. The dotted line shows the level of the back transfer necessary to achieve payoff equality between the investor and the trustee. The dashed line shows a level of back transfer equal to the investor's transfer to the trustee. The trustees' back transfers are on average slightly higher than the amount sent by the investor. Trustees in both treatment groups make higher back transfers in response to higher original investor transfer levels. However, there is no statistically significant difference in back transfers between subjects in the oxytocin and the placebo groups.

that the effect of oxytocin on human trust is not caused by non-specific, psychotropic effects of oxytocin.

What mechanisms might be involved in generating the effect of oxytocin on trusting behaviour? One possibility is that oxytocin causes a general increase in prosocial inclinations. This implies that oxytocin should affect not only the prosocial behaviour of the investors but also that of the trustees. We would therefore predict that those trustees who are given oxytocin should make higher back transfers at any given level than the trustees who received placebo. However, trustees given oxytocin do not show more trustworthy behaviour (Fig. 3). At every positive transfer level (4, 8 or 12 MU), their back transfers are statistically indistinguishable from those of placebo trustees (Mann Whitney *U*-tests; $P > 0.243$, two-sided tests for each positive transfer level). Thus, oxytocin does not increase the general inclination to behave prosocially. Rather, oxytocin specifically affects the trusting behaviour of investors.

We hypothesize that the differing effect of oxytocin on the behaviour of investors and trustees is related to the fact that investors and trustees face rather different situations. Specifically, investors have to make the first step; they have to 'approach' the trustee by transferring money. In contrast, the trustees can condition their behaviour on the basis of the investors' actions. Thus, the psychology of trust is important for investors, whereas the psychology of strong reciprocity[27] is relevant for trustees. The fact that oxytocin affects subjects' approach or trust behaviour, but not their degree of reciprocity, is in agreement with animal studies. There is substantial evidence that oxytocin promotes prosocial approach behaviour by inhibiting defensive behaviours[6,13], but there is no evidence that oxytocin affects reciprocity in animals.

A second mechanism behind the effect of oxytocin on trust could be based on subjects' beliefs. Oxytocin might render subjects more optimistic about the likelihood of a good outcome. In order to address this question, we measured the investor's subjective expectation about the trustee's back transfer after every transfer decision. A Mann-Whitney *U*-test indicates that these expectations do not differ significantly between oxytocin and placebo groups at every feasible positive transfer level ($P > 0.357$, two-sided tests at transfer levels of 4, 8 or 12 MU). Thus, the investors given oxytocin show more trusting behaviour but do not hold significantly different beliefs about the trustworthiness of others. Moreover, oxytocin does not affect investors' beliefs about the likelihood of a good outcome in the risk experiment ($P > 0.128$, two-sided Mann Whitney *U*-tests for transfer levels of 4, 8 or 12 MU).

Finally, there is the possibility that oxytocin helps subjects to overcome their betrayal aversion in social interactions. This explanation is consistent with the differing effects of oxytocin across the trust and the risk experiments, and is further supported by the fact that investors faced a considerable betrayal risk. An increase in the transfer level from 4 or 8 MU to 12 MU decreased the investor's average payoff slightly, whereas it increased the objective risk of very low back transfers by the trustee. However, betrayal aversion alone cannot explain why investors given oxytocin make higher transfers in the trust experiment compared with the risk experiment, because betrayal is impossible in the risk experiment. The higher transfers in the trust experiment can be reconciled with betrayal aversion if one acknowledges that investors' behaviour in the trust experiment is also likely to be driven by the motive to increase the available amount for distribution between the two players[28]. As this motive cannot operate in the risk experiment, it can only increase transfers levels in the trust experiment. Our interpretation of oxytocin's effect on trust in terms of betrayal aversion may be seen in the light of animal studies indicating that increased availability of oxytocin in the central nervous system facilitates approach behaviour, by linking the overcoming of social avoidance with the activation of brain circuits implicated in reward (for example, the nucleus accumbens)[12,15].

The ubiquity of trusting behaviour is perhaps one of the distinguishing features of the human species. An element of trust characterizes almost all human social interactions. Here we have sought to examine the effect of oxytocin on trust in humans. Research in non-human mammals suggests that oxytocin has a key role in social attachment and affiliation. We find that intranasal administration of oxytocin causes a substantial increase in trusting behaviour. Subjects given oxytocin seem better able to overcome trust obstacles such as betrayal aversion. Of course, this finding could be misused to induce trusting behaviours that selfish actors subsequently exploit. However, our findings may also have positive clinical implications for patients with mental disorders that are associated with social dysfunctions (for example, social phobia or autism). In particular, social phobia ranks as the third most common mental health disorder and is characterized by marked social deficits, including persistent fear and avoidance of social interactions. Thus, our results might lead to fertile research on the role of oxytocin in several mental health disorders with major public health significance.

METHODS

Subjects. A total of 194 healthy male students (mean age ± s.d., 22.0 ± 3.4 yr) from different universities in Zurich participated in the study. The trust experiment had 128 participants, and 66 subjects participated in the risk experiment. Exclusion criteria for participation were significant medical or psychiatric illness, medication, smoking more than 15 cigarettes per day, and drug or alcohol abuse. Subjects were instructed to abstain from food and drink (other than water) for 2 h before the experiment, and from alcohol, smoking and caffeine for 24 h before the experiment. Participants were informed at the time of recruitment that the experiment would evaluate the effects of a hormone on decision making. In total, 16 individuals out of the original sample of 194 were excluded because of incorrect substance administration (7 in the trust experiment, 5 in the risk experiment) or their stated disbelief that the opponent in the trust game was actually a human being (4 participants). The study protocol was approved by the ethics committee of the University of Zurich. All subjects gave written, informed consent before participation.

Substance administration. Subjects received a single intranasal dose of 24 IU oxytocin (Syntocinon-Spray, Novartis; 3 puffs per nostril, each with 4 IU oxytocin) or placebo 50 min before the start of the trust or the risk experiment. Subjects were randomly assigned to the oxytocin or placebo group (double-blind, placebo-controlled study design). In order to avoid any subjective substance effects (for example, olfactory effects) other than those caused by oxytocin, the placebo contained all inactive ingredients except for the neuropeptide.

Behavioural experiment and questionnaires. After substance administration,

© 2005 Nature Publishing Group

subjects completed questionnaires on a computer to measure demographic items and psychological characteristics. Owing to the crucial role of the social environment in triggering behavioural effects of oxytocin (as shown in animal research)[13,29], subjects were asked to wait in the rest area while the next part of the experiment was prepared. During this 5-min waiting period, subjects were seated at different tables. Subjects at the same table could talk to each other, but at the beginning of the experiment they were informed that they would not be interacting with those subjects who sat at the same table. When subjects re-entered the laboratory for both experiments, they received written instructions (available from the authors on request) explaining the payoff structure of the experiment and the private payment procedure at the end of the experiment. Subjects were randomly and anonymously assigned to the role of investor or trustee in the trust experiment, and did not know the identity of the persons with whom they were matched. After subjects had read the instructions in each experiment, we checked whether they understood the payoff structure by means of several hypothetical examples. All subjects (with one exception) answered the control questions correctly. One subject did not answer the control questions correctly and was excluded from the data set (this subject also did not apply the substance correctly). In addition, subjects received an oral summary of the instructions.

Each subject in the trust experiment made four decisions in the same player role while paired with different, randomly selected interaction partners. No pair of subjects interacted twice. Subjects in the role of the investor received no feedback about the trustee's decision between the different interactions. After every transfer decision, each investor was asked about his belief with regard to the expected back transfer from the trustee. Notably, trust levels were statistically constant across the four decisions. There is no time trend in investors' decisions in either the oxytocin or the placebo group. In the risk experiment, everything was identical to the trust experiment, except that all subjects played the role of an investor who could transfer 0, 4, 8, or 12 MU into a project rather than to a trustee. In particular, an investor's payoff risk (that is, the distribution of payoffs) in the risk experiment was identical to that in the trust experiment at any feasible transfer level.

To measure alterations in the psychological state of subjects throughout the course of the experiment, we assessed their mood and calmness at the beginning of the experiment (before substance administration) and immediately before the trust experiment or the risk experiment, by means of a suitable questionnaire[26]. All decisions in the experiments and the answers to the questionnaires were entered on a computer using z-Tree software[30]. Subjects received a flat fee of 80 Swiss francs for participation in the experiment; each MU earned in the trust and the risk experiment was worth 0.40 Swiss francs.

Received 20 April; accepted 5 May 2005.

1. Luhmann, N. *Trust and Power* (Wiley, New York, 1979).
2. Coleman, J. *Foundations of Social Theory* 91–118 (Belknap Press of Harvard Univ. Press, Cambridge, 1990).
3. Arrow, K. Gifts and exchanges. *Phil. Publ. Affairs* **1,** 343–362 (1972).
4. Knack, S. & Keefer, P. Does social capital have an economic payoff? A cross-country investigation. *Q. J. Econ.* **112,** 1251–1288 (1997).
5. Zak, P. J. & Knack, S. Trust and growth. *Econ. J.* **111,** 295–321 (2001).
6. Carter, C. S. Neuroendocrine perspectives on social attachment and love. *Psychoneuroendocrinology* **23,** 779–818 (1998).
7. Uvnas-Moberg, K. Oxytocin may mediate the benefits of positive social interaction and emotions. *Psychoneuroendocrinology* **23,** 819–835 (1998).
8. Insel, T. R. & Young, L. J. The neurobiology of attachment. *Nature Rev. Neurosci.* **2,** 129–136 (2001).
9. Landgraf, R. & Neumann, I. D. Vasopressin and oxytocin release within the brain: a dynamic concept of multiple and variable modes of neuropeptide communication. *Front. Neuroendocrinol.* **25,** 150–176 (2004).
10. Huber, D., Pierre, V. & Ron, S. Vasopressin and oxytocin excite distinct neuronal populations in the central amygdala. *Science* **308,** 245–248 (2005).
11. Carter, C. S., Altemus, M. & Chrousos, G. P. Neuroendocrine and emotional changes in the post-partum period. *Prog. Brain Res.* **133,** 241–249 (2001).
12. Young, L. J., Lim, M. M., Gingrich, B. & Insel, T. R. Cellular mechanisms of social attachment. *Horm. Behav.* **40,** 133–138 (2001).
13. Pedersen, C. A. Oxytocin control of maternal behavior. Regulation by sex steroids and offspring stimuli. *Ann. NY Acad. Sci.* **807,** 126–145 (1997).
14. Heinrichs, M., Neumann, I. & Ehlert, U. Lactation and stress: protective effects of breast-feeding in humans. *Stress* **5,** 195–203 (2002).
15. Insel, T. R. & Shapiro, L. E. Oxytocin receptor distribution reflects social organization in monogamous and polygamous voles. *Proc. Natl Acad. Sci. USA* **89,** 5981–5985 (1992).
16. Born, J. *et al.* Sniffing neuropeptides: a transnasal approach to the human brain. *Nature Neurosci.* **5,** 514–516 (2002).
17. Heinrichs, M., Baumgartner, T., Kirschbaum, C. & Ehlert, U. Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biol. Psychiatry* **54,** 1389–1398 (2003).
18. Heinrichs, M., Meinlschmidt, G., Wippich, W., Ehlert, U. & Hellhammer, D. H. Selective amnesic effects of oxytocin on human memory. *Physiol. Behav.* **83,** 31–38 (2004).
19. Camerer, C. & Weigelt, K. Experimental tests of a sequential equilibrium reputation model. *Econometrica* **56,** 1–36 (1988).
20. Fehr, E., Kirchsteiger, G. & Riedl, A. Does fairness prevent market clearing? An experimental investigation. *Q. J. Econ.* **108,** 437–459 (1993).
21. Berg, J., Dickhaut, J. & McCabe, K. Trust, reciprocity and social history. *Games Econ. Behav.* **10,** 122–142 (1995).
22. Bohnet, I. & Zeckhauser, R. Trust, risk and betrayal. *J. Econ. Behav. Organ.* **55,** 467–484 (2004).
23. Holt, C. & Laury, S. Risk aversion and incentive effects. *Am. Econ. Rev.* **92,** 1644–1655 (2002).
24. Fehr, E. & Schmidt, K. M. A theory of fairness, competition, and cooperation. *Q. J. Econ.* **114,** 817–868 (1999).
25. Hong, K. & Bohnet, I. *Status and Distrust: the Relevance of Inequality and Betrayal Aversion* (Working Paper RW04-041, Kennedy School, Harvard Univ., Cambridge, 2004).
26. Steyer, R., Schwenkmezger, P., Notz, P. & Eid, M. *Der Mehrdimensionale Befindlichkeitsfragebogen (MDBF)* [Multidimensional mood questionnaire] (Hogrefe, Göttingen, 1997).
27. Gintis, H., Bowles, S., Boyd, R. & Fehr, E. Explaining altruistic behavior in humans. *Evol. Hum. Behav.* **24,** 153–172 (2003).
28. Engelmann, D. & Strobel, M. Inequality aversion, efficiency, and maximin preferences in simple distribution experiments. *Am. Econ. Rev.* **94,** 857–869 (2004).
29. Kendrick, K. M. *et al.* Neural control of maternal behaviour and olfactory recognition of offspring. *Brain Res. Bull.* **44,** 383–395 (1997).
30. Fischbacher, U. *z-Tree. Zurich Toolbox for Readymade Economic Experiments* (Working Paper No. 21, Institute for Empirical Research in Economics, Univ., Zurich, 1999).

Acknowledgements This paper is part of the Research Priority Program 'Foundations of Human Social Behaviour—Altruism versus Egoism' at the University of Zurich. Financial support from the MacArthur Foundation (Network on Economic Environments and the Evolution of Individual Preferences and Social Norms) and the Cogito Foundation is gratefully acknowledged. M.H. also acknowledges support from the Swiss National Science Foundation. We thank F. Heusi, A. Enzler, S. Gilomen, E. Götz, M. Koenigsberg, K. Korsunsky, S. Krammer, S. Lauber, P. Obrist-Rybar, M. Schellhammer, B. Studer, R. Stünzi and M. Trottmann for research assistance.

Author Information Reprints and permissions information is available at npg.nature.com/reprintsandpermissions. The authors declare no competing financial interests. Correspondence and requests for materials should be addressed to E.F. (efehr@iew.unizh.ch) and M.H. (m.heinrichs@psychologie.unizh.ch).

© 2005 Nature Publishing Group

Copyright of Nature is the property of Nature Publishing Group and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.